TECHNICAL MEMORANDUM

NO. 11

UTILIZATION OF THE VEGETATION INDEX NUMBER IN THE USSR

CROP CONDITION ASSESSMENT DIVISION

UNITED STATES DEPARTMENT OF AGRICULTURE
FOREIGN AGRICULTURAL SERVICE

HOUSTON, TEXAS

UTILIZATION OF THE VEGETATION INDEX NUMBER IN THE USSR

FIRST ISSUE

APPROVED BY:

James R. Hickman

James R. Hickman, Director
Crop Condition Assessment Division

1 REASON FOR ISSUANCE

To document and evaluate the crop condition assessment procedure involving the vegetative index numbers in the USSR for 1978 and 1979.

2 COVERAGE

The results of this report will be used to assess present and future crop condition assessment techniques used in the USSR.

3 CONCURRENCE

Bobby E. Spiers

Acting Chief, Commodity Analysis Branch
Crop Condition Assessment Division

4 PREPARED BY:

Pat Ashburn

Pat Ashburn, Crop Condition Assessment Division

5/18/81

Date

TABLE OF CONTENTS

	Page No.
PART 1.0 INTRODUCTION	1-1
1.1 Purpose	1-1
1.2 Scope	1-1
1.3 Background	1-1
PART 2.0 THE VEGETATIVE INDEX NUMBER CROP CONDITION PROCESS	2-1
2.1 How the VIN is Calculated	2-1
2.2 The Segment Level VIN	2-1
2.2.1 VINSEG.DAT	2-1
2.2.2 VINPLT.DAT	2-1
2.2.3 VINPLOT.DAT	2-2
2.2.4 VIN Maps	2-2
2.2.5 Crop Vigor/Expected Yield Table	2-2
Figure 1. Vegetative Index Numbers (AVI) Segment Average in Northern Kazakhstan, USSR	2-3
Table 1. Expected Yield/Segment Average AVI for Spring Grains East of the Volga River, USSR	2-4
2.2.6 The Crop VIN	2-2
2.2.7 VIN Crop Maps	2-5
2.2.8 The Spring Wheat Yield Table	2-5
Table 2. Spring Grains Yield Curves	2-6
2.2.9 VIN Curves	2-5
Table 3. Estimated Spring Wheat Yields Derived from Vegetative Index Numbers for 1979	2-7
Figure 2. Vegetation Index Curves for Kustanay Oblast	2-8
PART 3.0 CONCLUSIONS AND RECOMMENDATIONS	3-1
3.1 Conclusions	3-1
3.2 Recommendations	3-1
EXHIBIT 1 REFERENCES	E-1

UTILIZATION OF THE VEGETATION INDEX NUMBER IN THE USSR

PART 1.0 INTRODUCTION

1.1 PURPOSE

The purpose of this paper is to report the development and use of Vegetation Index Number (VIN) crop condition assessment indication models in the USSR.

1.2 SCOPE

The scope of this paper is limited to the transformation of LANDSAT multispectral (MSS) data into vegetation index numbers that are used to develop vigor and yield models for USSR crops.

1.3 BACKGROUND

The United States Department of Agriculture has a requirement to provide current analysis of foreign crop production. This requirement led to the establishment of a new division within the Foreign Agricultural Service (FAS) designed to take advantage of advanced satellite technology. This division, the Crop Condition Assessment Division (CCAD), is presently located in Houston, Texas. Its primary function is to monitor, assess and report the condition of crops in several countries. To satisfy these requirements, the CCAD has developed operational capabilities including a geogridded reference data base, an interactive image processing system and a rapid image transformation system.

"An Evaluation of Relationships Between Vegetative Indices, Soil Moisture and Wheat Yields"[1] and "The Utilization and Evaluation of Vegetative Indices for Crop Condition Assessment"[2] were published by the CCAD as documentation of VIN procedures. These two publications along with "Vegetation Condition Assessment Over Very Large Areas,"[3] "The Vegetative Index Number and Crop Identification,"[4] and "The World Wheat Situation and a Color Composite Method for Monitoring Winter Wheat on ERTS Imagery"[5] describe the history, techniques and methods used by CCAD. The first four publications deal with LANDSAT digital data of 117 by 196 picture elements (pixels). This paper is intended to describe the processes for locating growing vegetation, isolating the crop of interest and calculating the corresponding VIN in the USSR.

PART 2.0 THE VEGETATIVE INDEX NUMBER CROP CONDITION PROCESS

2.1 HOW THE VIN IN CALCULATED

The VIN used for developing vigor and yield tables in the USSR is 2 times Band 7 minus Band 5 (2x7-5) of the LANDSAT MSS data. All negative values are set to Ø and are not considered green. Only positive values are considered to be growing vegetation. With the advent of the High Density Tape format introduced by NASA in October 1979, the formula will be Band 7 minus Band 5. This calculation requires approximately 15 seconds on a PDP 11/7Ø computer.

2.2 THE SEGMENT LEVEL VIN

The segment level VIN is derived from calculating a VIN for each of the 22,932 pixels in a 5 by 5 nautical mile segment of LANDSAT data. All the positive values (values>Ø) are added together and an arithmetic mean is calculated. This mean value is known as the segment level VIN. It is calculated in approximately 20 seconds on a PDP 11/7Ø computer. Each VIN and its segment number, Julian date, percent of good data, number of positive pixels and average are stored in an on-line file called VINSEG.DAT.

2.2.1 VINSEG.DAT. This file is periodically sorted so that all acquisitions of the same segment number are located together. The present file has historical data of the USSR dating from the fall of 1975 through the present. Limited additional data from the U.S., Canada, Australia, India, Argentina and Brazil are also stored in the file. VIN's are automatically added to this file through batch programs that read either tape or disk stored data. The file currently has VIN's from some 4Ø,ØØØ acquisitions. These data are retrieved through the Data Base Management System or through the use of specially developed software called VINPLT.DAT.

2.2.2 VINPLT.DAT. This program has been developed to retrieve VIN's from the VINSEG.DAT file. Its primary function is to provide the analyst with options to specify which dates, locations (countries), and which of the nine different VIN's are being requested. Of the nine different VIN's only one will be discussed in this paper. The Ashburn Vegetation Index (AVI) number has been used exclusively in the USSR and will be referred to hereafter as the VIN. For the USSR, VIN's for a block of 18 consecutive days are used. Eighteen consecutive days are required to provide total coverage of the USSR. Although 18 day periods are used for the USSR, any set of 1 to 17 days can be retrieved for smaller areas of study. These days are defined by Julian dates. Caution should be taken to avoid retrieving data more than 18 days apart. This may result in pulling data for the same location but for a later time period. Data retrieval using this program is then used for statistical analyses or for plotting on maps. The plotting program is called VINPLOT.DAT.

2.2.3 VINPLOT.DAT. This program was developed in order that VIN's could be plotted quickly on the computer generated maps used in the program. The program requires the selection of a computerized map base and the appropriate VIN plot data file. The map selection defines the area. This program verifies the geographic coordinates from each of the VIN's in the VINPLT.DAT file and prints out the VIN at its appropriate location. Map transparencies at the same scale and projection as the computer generated map are used to view the political locations of each of the VIN numbers.

2.2.4 VIN Maps. These are the hardcopy maps that are generated by the previous two programs. The maps for the USSR date from the fall of 1975 and are maintained through the present. A map is produced every 18 days. The values on the maps are compared to the values from previous years. This comparison provides a relative change detection capability based on knowledge of previous years' crop conditions. Isoline maps are drawn depicting the magnitude of change from one year to the next. Isolines depicting areas of excessive vegetative stress or exceptionally good vegetative conditions are noted. The isolines of the VINMAP provide an exceptionally good synoptic view of vegetative conditions across the whole of the USSR. Abnormal conditions are located and measured for possible impact to subsequent crop yields. An example of the VINMAP is shown in Figure 1.

2.2.5 Crop Vigor/Expected Yield Table. This table (Table 1) is used to depict a relative grain yield directly from the VIN values and to provide alert information automatically to the analyst. VIN's are compared to their corresponding yield values. This is done by locating areas of reported yields published by the USSR. These are usually Rayon or farm level yields. Attache reports of farm yields are also used on a continuing basis to upgrade and improve the table. Since the segment level VIN measures all growing vegetation, the values have a wide yield range. A primary use of this table is to provide expected upper and lower bounds for crop conditions. When the VIN is outside the expected range for the Julian date, the analyst attempts to determine the cause and impact of the deviation. It is important to note that all vegetation are measured for use in this table including but not limited to the crops of interest. As the number of crop related pixels increase, the reliability of the table increases.

2.2.6 The Crop VIN. The crop level VIN is derived from averaging the pixel values that represent the crop. This is accomplished by drawing a boundary around the field or fields of interest and calculating the VIN for these fields. This is known as the field procedure. The LANDSAT scene/segment is clustered and the clusters representing the crop of interest are combined and a VIN is calculated for the cluster. This is the cluster/classification procedure. A VIN image is created and the crop of interest is located through a histogram of the data. The crop mask created from this method is then calculated for a VIN. This is the masking procedure. Because the masking procedure is generally the fastest

FIGURE 1. VEGETATIVE INDEX NUMBERS (AVI) SEGMENT AVERAGE IN NORTHERN KAZAKHSTAN, USSR

June 19 to July 6, 1978

TABLE 1. EXPECTED YIELD/SEGMENT AVERAGE AVI FOR SPRING GRAINS

EAST OF THE VOLGA RIVER, USSR

EXPECTED YIELD C/HA*	AVERAGE AVI NUMBER JULIAN DATES FOR EACH 18 DAY PERIOD					
	116-133	134-151	152-169	170-187	188-205	206-223
21-26	>9	>13	20+	32+	31+	31+
15.5-21	>9	>13	19	26-31	26-30	28-31
9.6-15.5	<9	9-12	11-15	19-25	19-25	16-27
5.9-9.5	NOT	5-8	5-10	11-18	11-18	10-15
3.1-5.9	RELI-	< 5	4	8-10	6-10	5-9
<3.0	ABLE	NOT RELI-ABLE	1-3	<5	<6	1-4

*Max Potential 26 C/HA Spring Grains

method, it was used in the USSR in creating crop VIN's. The numbers calculated from any of the three procedures are stored in a file called VINCRP.DAT. This file is similar to the VINSEG.DAT in structure and is used in the same way. The VINCRP.DAT currently has two years of data for much of the spring wheat area east of the Volga River in the USSR. It also holds ground truth data from selected U.S. and Canadian ground truth sites. From this file, crop level VIN maps are produced.

2.2.7 VIN Crop Maps. These maps are produced much like the VINSEG maps. They are used to get a synoptic view of crop vigor and yield levels across the USSR. Isolines are drawn on these maps to identify equal areas of vigor/yield. Yield information derived from the area of crop VIN's is compared at the individual scene or segment level and at the oblast level. All the values calculated inside an oblast are averaged for each time period. This average crop VIN for the oblast is compared to the oblast spring wheat or spring grains yield as reported by the USSR.

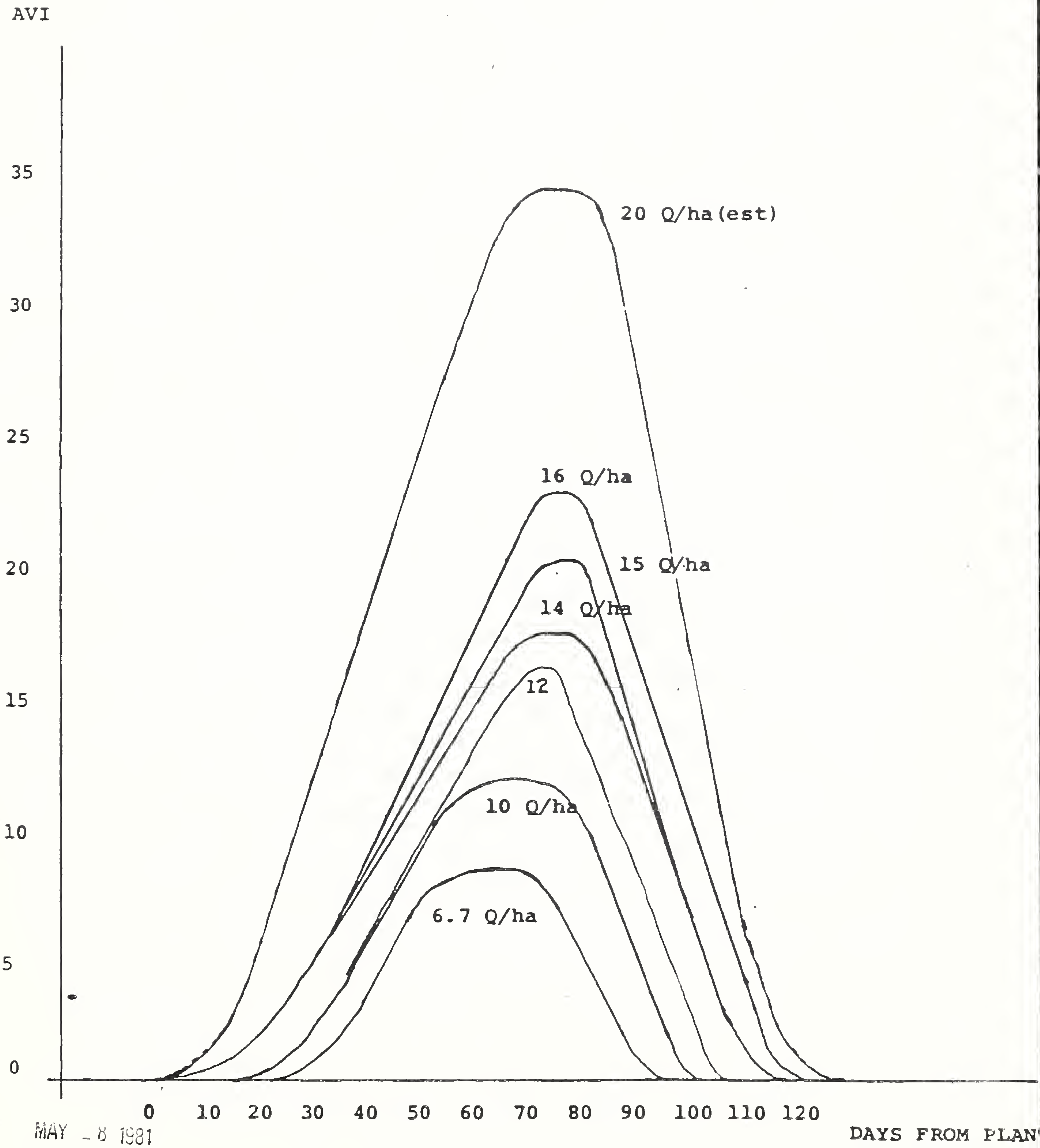
2.2.8 The Spring Wheat Yield Table. This table (Table 2) shows the results of yield reports and crop VIN's against time. Both reported yields from the USSR and ground truth values from the U.S. and Canada are represented in the various yield curves in the table. The VIN is plotted on the Y axis; the number of days from planting and a crop calendar are plotted on the X axis.

When new yield information is received from the USSR, it is first used to test the accuracy of the yield table and then it is incorporated into the table.

Thus far, the accuracy of the table has been $\pm$1.0 centners when compared to oblast level yields of the 1978 crop year. Indications are that this level of accuracy will be maintained for the 1979 crop year. For 1979, 12 oblasts or krays (Table 3) in the USSR have yield estimates derived from Table 2. These estimates are shown in Table 3. Also shown in Table 3 are average yields, and the estimate from the VIN/soil moisture yield model. Caution should be used in overreliance on the yield estimates derived from the yield models because neither model has been tested fully nor have they been used long enough to produce adequate reliability data.

2.2.9 VIN Curves. Both the segment level VIN and the crop VIN are plotted over time for each year. Figure 2 is a graph showing the oblast level VIN for Kustanay Oblast. These data are used to visualize the relative vigor of the oblast from one year to the next. Also on the graph is one plot of the crop level VIN for 1979. This shows the relationship between the oblast level VIN and the oblast level crop VIN for 1979. Because of the vegetation characteristics and growing times, each oblast will have its own characteristic curve.

TABLE 2. SPRING GRAINS YIELD CURVES
(East of Volga River USSR)



OBLASTS	1970-1974 AVG. YIELD	ESTIMATED YIELD SPRING WHEAT 1979	REDUCTION DUE TO LATE HARVEST		*REPORTED YIELD IN TOTAL GRAIN
ALTAY	13.3	13.1			13.4
BASHKIR	14.1	19.3	17%	(16.0)	15.9
KEMEROVO	13.8	18.0	5%	17.6	
KOKECHETAV	12.1	18.7	6%	17.6	14.5
KURGAN	16.0	19.6	11%	17.6	17.3
KUSTANAY	9.7	17.3	16%	(14.5)	13.3
NOVOSIBIRSK	13.0	19.3	6%	(18.3)	
OMSK	14.5	19.3	11%	(17.3)	18.5
ORENBURG	11.5	11.0			13.5
PAVLODAR	7.7	11.0			
SEVERO-KAZAKH	14.6	20.2	10%	(18.0)	18.3
TSELINOGRAD	10.0	15.5			16.5

*MOST OF THE CROPLAND IS SOWN TO SPRING WHEAT

Table 3 Estimated Spring Wheat Yields Derived From VIN's For 1979

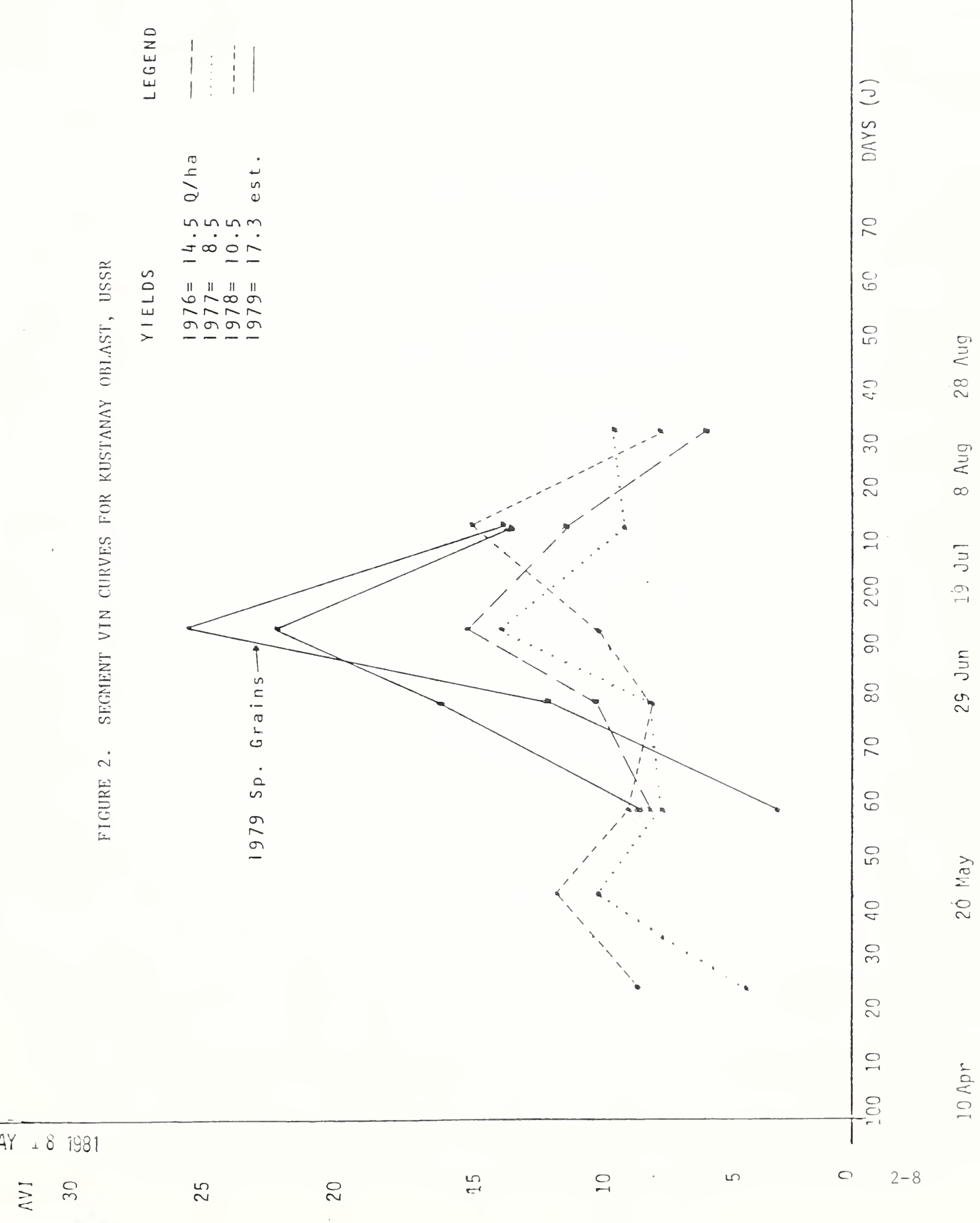


FIGURE 2. SEGMENT VIN CURVES FOR KUSTANAY OBLAST, USSR

PART 3 CONCLUSIONS AND RECOMMENDATIONS

3.1 CONCLUSIONS

- Segment level VIN's are difficult to interpret, especially when they are viewed individually.
- Segment level VIN's provide a good indication of the condition of the vegetation of a segment area but not necessarily the crop of interest.
- Segment level VIN's, when viewed synoptically, provide a good indication of area vegetation conditions.
- Segment level VIN's, when compared at approximately the same time, year after year, provide a good relative difference in vegetation condition from year to year.
- Oblast level VIN's have a fair relationship to oblast yields.
- High VIN's are closely related to vigorous vegetation growth.
- Low VIN's are closely related to poor vegetative growth.
- Segment level VIN's can be used to alert analysts of abnormal conditions.
- Crop VIN's provide a very good indication of oblast wheat yields.
- Crop VIN's are a good source for determining when flowering occurs in small grains.
- Although the tables presented in this paper are providing accurate data, caution should be used in relying too heavily upon the results. Considerable other data are also used to produce a yield/production estimate. Also, these data may be country specific.

3.2 RECOMMENDATIONS

- Identify additional economic crops and develop oblast level yield tables that are reflected by VIN's.
- Use as many crop pixels as possible for calculating average VIN's.
- When possible, develop crop VIN masks for a total oblast.
- Validate the methods reported in this paper in other countries and other crops.
- Include negative VIN values when calculating crop average VIN's.

REFERENCES

1. Aaronson, A., and Davis, L., "An Evaluation of Relationships Between Vegetative Indices, Soil Moisture and Wheat Yields," TM-9 (September 19, 1979), The Crop Condition Assessment Division, FAS/USDA.

2. Davis, L., "Utilization and Evaluation of Vegetative Indices for Crop Condition Assessment," TM-1Ø (September 17, 1979), The Crop Condition Assessment Division, FAS/USDA.

3. Ashburn, P., "Vegetation Condition Assessment Over Very Large Areas," April 1979, The Crop Condition Assessment Division, FAS/USDA.

4. Ashburn, P., "The Vegetative Index Number and Crop Identification," The LACIE Symposium, Proceedings of Technical Sessions, Volume II, Page 843, JSC-16Ø15, Houston, Texas, October 1978.

5. Ashburn, P., "The World Wheat Situation and a Color Composite Method for Monitoring Winter Wheat on ERTS Imagery," Cornell University, December 1974.

a